STAFF SUMMARY SHEET

	TO	ACTION	SIGNATURE (Surname), GRADE AND DATE		TO	ACTION	SIGNATURE (Surname), GRADE AND DATE
1	DFER	Approve	Solti, AD, 25, 26 Feb 16	6			
2	DFB	Action		7			
3				8			
4				9			
5				10			

SURNAME OF ACTION OFFICER AND GRADE	SYMBOL	PHONE	TYPIST'S INITIALS	SUSPENSE DATE
Dr. David Westmoreland	DF	333-2469	mk	Not Applicable

SUBJECT: Clearance for Material for Public Release

USAFA-DF-PA- 2016-169

DATE: 20160226

SUMMARY

1. PURPOSE. To provide security and policy review on the document at Tab 1 prior to release to the public.

2. BACKGROUND.

Authors: Westmoreland, David.

Title: Assessment of scientific reasoning as an institutional outcome.

Release Information: This presentation will be given at the Scholarship of Teaching & Learning Commons, 30 Mar - 01 April 2016, Savannah, GA

3. DISCUSSION. N/A

4. VIEWS OF OTHERS. N/A

5. RECOMMENDATION. Sign coord block above indicating document is suitable for public release. Suitability is based solely on the document being unclassified, not jeopardizing DoD interests, and accurately portraying official policy.

MARCUS D. KING, Lt Col, USAF, PhD
Senior Military Faculty and Deputy for Research

Tab
1. Abstract
2. Presentation slides

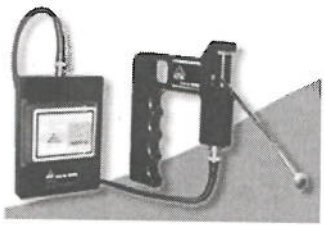
The US Air Force Academy has established 9 institutional outcomes, each of which is assessed by a team of 5 - 10 faculty and staff members with expertise in the outcome domain. Student achievement of the "Scientific Reasoning and Principles of Science" was assessed in the 2012-13 academic year by sampling 203 students distributed across freshman-to-senior class years. Two assessment instruments were used: (a) an in-house survey of student understanding of the Nature of Science, and (b) the Lawson test of scientific reasoning. Students showed statistically significant gains in both scores between the sophomore and junior years. Student understanding of the Nature of Science did not differ by program of study, but students in the basic sciences and engineering scored significantly higher than students in the humanities on the scientific reasoning assessment. Overall, students were weakest when answering questions related to (a) proportional reasoning, (b) isolation of variables, and (c) if-then reasoning. These findings are being incorporated into a redesign of the core curriculum to enhance continuity among science courses in presenting the Nature of Science, and coordination among basic sciences course directors to align efforts to teach scientific reasoning.

Assessment of Scientific Reasoning as an Institutional Outcome

01 April 2016

Dr. David Westmoreland
Senior Associate Dean
United States Air Force Academy

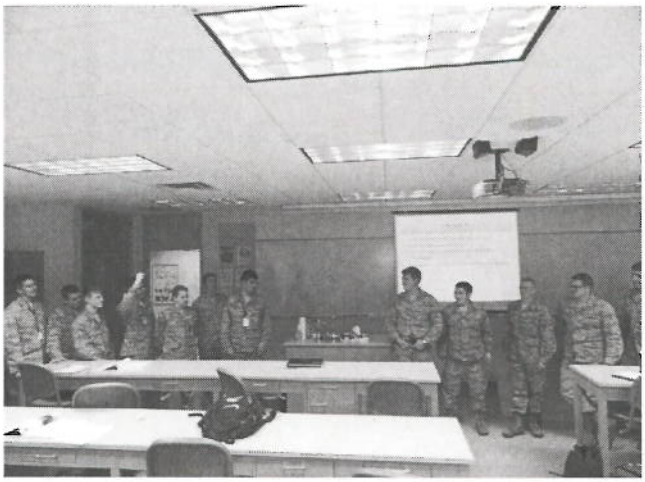
The Need for Scientific Literacy



The ADE 651 is a "remote portable Substance detector"

$ 10K – 60K per unit

The Need for Scientific Literacy, Part II



Courses that are Explicitly Designed to Emphasize Science

Freshman Yr
- Beh Sci 110
- Chem 100
- Physics 110

Sophomore Yr
- Chem 200
- Physics 115

Junior Yr
- Beh Sci 310
- Biology 315

Senior Yr
- Mgt 400

Approach of the Assessment Team

- Semi-random sample to assess:
  - Comprehension of the scientific method as a way of understanding the natural world (Instrument A)
  - Application of scientific reasoning to solve questions (Instrument B)

Instrument A

(Score ranges from 0 – 12)

Designed to assess whether students comprehend the fundamentals of science as a way of thinking:

- What is the goal of science?
- What are the limitations of scientific inquiry?
- How are the principles of empiricism, skepticism, and rationalism applied?
- What is the distinction between fact, law, theory?

Question	Strongly Agree
1. The primary purpose of science is the improvement of the quality of life for humanity.	
2. Scientific investigations are limited to the natural world (matter, energy, and their interactions).	
3. The overarching goal of science is to collect as many facts about nature as possible.	
4. A scientific theory is an explanation that has been substantiated by extensive observation and testing.	
5. Scientists must be accepting of all findings of their fellow researchers.	
6. If a series of experiments fail to support a hypothesis, scientists look for other ways to support it.	
7. A theory is elevated to the level of law when it has been validated by repeated experiments.	
8. To be considered scientific, an idea must be empirically testable.	
9. To make any scientific determination about a past occurrence in nature, there must have been direct human observation of that occurrence.	
10. When the scientific method is used properly, conclusions are definite.	
11. Supernatural explanations are occasionally incorporated into scientific explanations.	
12. Some areas of science (e.g., astronomy, chemistry) use principles or laws that contradict those used by other disciplines.	

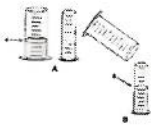
Instrument B

(Score ranges from 0 – 12)

Designed to assess whether students effectively apply scientific reasoning to solve problems. Assesses:

- Proportional reasoning (example →)
- Correlational reasoning
- Probabilistic prediction
- Isolation of variables
- Hypothetico-deductive (If, Then) reasoning
- Conservation of matter

5. To the right are drawings of a wide and a narrow cylinder. The cylinders have equally spaced marks on them. Water is poured into the wide cylinder up to the 4th mark (see A). This water rises to the 6th mark when poured into the narrow cylinder (see B).



Both cylinders are emptied (not shown) and water is poured into the wide cylinder up to the 6th mark. *How high would this water rise if it were poured into the empty narrow cylinder?*

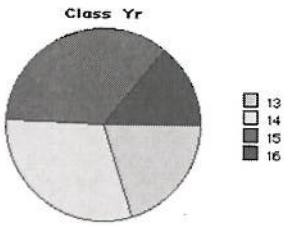
a. to about 8
b. to about 9
c. to about 10
d. to about 12
e. none of these answers is correct

6. *because*

a. the answer can not be determined with the information given
b. it went up 2 more before, so it will go up 2 more again.
c. it goes up 3 in the narrow for every 2 in the wide.
d. the second cylinder is narrower.
e. one must actually pour the water and observe to find out.

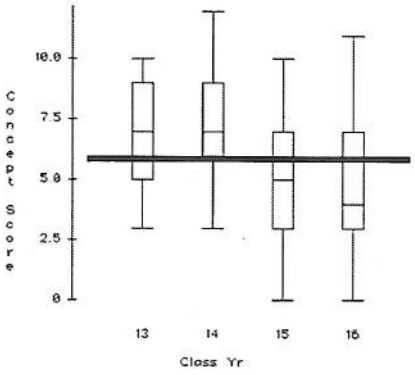
Jan 2013

- We sampled cadets taking Physics 100, Chem 200, Biology 315, and Strategic Studies 416
- N = 203 cadets
- Data recorded:
  - Scores on both instruments
  - Class year
  - Academic division
  - Core, Maj, Cum GPA

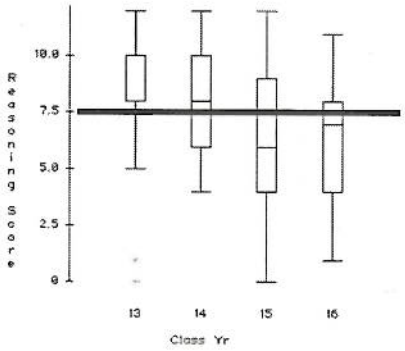


What Happens as Cadets Progress Through the Curriculum?

Conceptualization of Science as a Way of Knowing

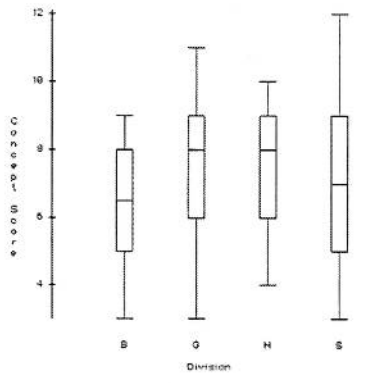


Scientific Reasoning/Problem solving

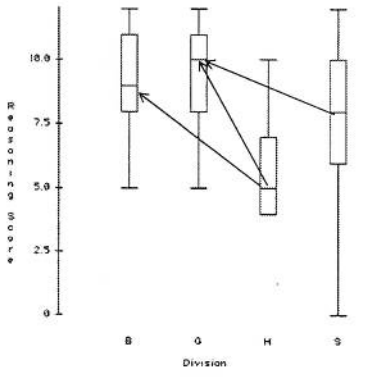


Does Academic Division Matter?

Conceptualization of Science as a Way of Knowing

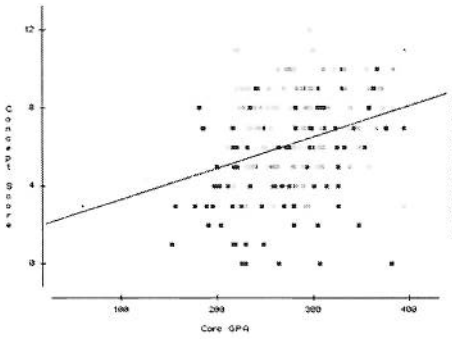


Scientific Reasoning/Problem solving

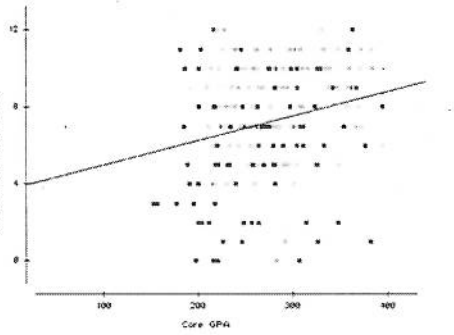


Does Core GPA Correlate?

Conceptualization of Science as a Way of Knowing (r = 0.335)



Scientific Reasoning/Problem solving (r = 0.235)



Which Factors are Significantly Related to Assessment Scores?

Conceptualization of Science as a Way of Knowing

Class year	P = 0.02
Division	P = 0.29
Core GPA	P = 0.01
Major GPA	P = 0.42
Class Yr*Division	P = 0.14

Scientific Reasoning/Problem solving

Class year	P = 0.03
Division	P = 0.09
Core GPA	P = 0.25
Major GPA	P = 0.69
Class Yr*Division	P = 0.21

Summary of Assessment Findings

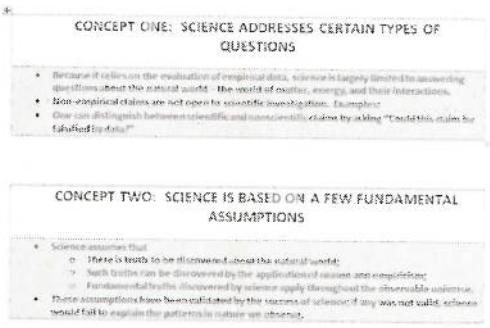
- Cadets show a significant improvement in Conceptualization of Science and Scientific Reasoning between 3-degree & 2-degree years
- Conceptualization of Science: Firsties and 2-degrees score low, regardless of Division
- Scientific Reasoning: Firsties and 2-degrees score about the same as reported in another study;
- Cadets in science-focused Divisions tend to have better skills in scientific reasoning and problem solving

Summary con't.

- Core GPA correlates weakly with both assessment scores

A WAY FORWARD
Conceptualization of Science

- Biology 480
  - Explicit instruction on science as a way of thinking is effective
- The Core
  - Coordinate the core science classes to introduce and reinforce the fundamentals of scientific thinking



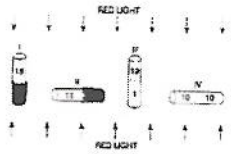
CONCEPT ONE: SCIENCE ADDRESSES CERTAIN TYPES OF QUESTIONS

CONCEPT TWO: SCIENCE IS BASED ON A FEW FUNDAMENTAL ASSUMPTIONS

A WAY FORWARD
Scientific Reasoning

- Our students are weakest on
  - Proportional reasoning (57.5% correct)
  - Isolation of variables (47% correct, ex: →)
  - If, then reasoning (35% correct)

Twenty fruit flies are placed in each of four glass tubes. The tubes are sealed. Tubes I and II are partially covered with black paper; Tubes III and IV are not covered. The tubes are placed as shown. Then they are exposed to red light for five minutes. The number of flies in the uncovered part of each tube is shown in the drawing.



This experiment shows that flies respond to (respond means move to or away from):

a. red light but not gravity
b. gravity but not red light
c. both red light and gravity
d. neither red light nor gravity